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RESEARCH ARTICLE

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Acute Effects of Acupuncture Treatment with Baihui (GV20) on Human Arterial Stiffness and Wave Reflection

Hiroyasu Satoh*

Department of Pharmacology, Division of Traditional Herbal Medicine, Nara Medical University, Kashihara, Nara, Japan

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Abstract
Objectives: Treatment by manual acupuncture needling affects the vascular wall tone, and hemodynamic parameters for arterial stiffness may be characterized by treatment at the traditional acupuncture point (acupoint) of Baihui (GV20).
Methods: The acute effects of acupuncture treatment on arterial stiffness and wave reflection were investigated and, simultaneously, an augmentation index (AI), as an index of wave reflection, was estimated. These parameters were measured in male volunteers using applanation tonometry during 20 minutes of acupuncture treatment and 40 minutes post-acupuncture.
Results: During treatment, diastolic blood pressure (BP), but not systolic BP, increased significantly. Heart rates (HR) initially tended to increase and then decrease. The AI from radial arteries increased significantly, while central aortic blood pressure (CBP) was unaffected. Post-acupuncture, the effects lasted for 30–40 minutes. The average BP and HR were $+10.1 \pm 0.3\%$ and $-7.2 \pm 0.2\%$, respectively, and the CBPs were not altered, but the AI decreased markedly; this latter effect presumably resulted from the involvement of neurovascular modulators.
Conclusions: These results indicated that acute treatment at Baihui enhanced arteriosclerotic parameters. In post-acupuncture, the AI profoundly decreased, presumably resulting from the involvement with neurovascular modulators.

1. Introduction

The use of acupuncture treatment has been accepted worldwide, its efficacy possibly because it functions through brain chemistry alterations including changing the release of neurotransmitters and neurohormones, thus resulting in modulation of BP, blood flow, and body temperature. Meridians are special lines distributed longitudinally on the human body and believed to play a role for regulating the viscera.

The pulse waveform in circulation depends on two factors: arterial stiffness with increased pulse-wave velocity (PWV) and a progressively earlier wave reflection. Pulse waveform is generated by the superposition of the reflected backward wave on the incident forward wave [1]. Pressure wave-contour

*Corresponding author. Department of Pharmacology, Nara Medical University, Kashihara, Nara 634–8521, Japan.
E-mail: hysat@naramed-u.ac.jp

analysis is a key descriptor of arterial elastic properties and a prognosticator of cardiovascular risk. An augmentation index (AI) has been established as a reflection coefficient determined by a computer algorithm developed from invasive pressure and flow data [2]. The reflected pressure wave is closely related to central aortic blood pressure (CBP) and cardiac afterload depends on CBP rather than on the peripheral brachial BP [3,4]. Central arterial stiffening causes pulse pressure differences (between systolic and diastolic pressure) to widen and can lead to isolated systolic hypertension syndrome. In terms of arterial properties, the AI depends not only on systemic arterial elasticity but also on arterial geometry and tone [5,6].

The acupoints of meridians utilized for BP regulation are known and acupuncture treatments appear to enhance the nitric oxide (NO) generation and increase local circulation [7,8]. However, there is less information available regarding acupuncture therapy with Baihui stimulation for altering cardiovascular functions. The Baihui is classified as a GV20 in the healing pressure points of governor vessel (GV), according to WHO guidelines [9]. The goal of the present study was to examine the effects of acupuncture with Baihui treatment on hemodynamic functions and to investigate the effects on the arterial pulse wave form using a combination of the ejection and reflection pulses, regarded to be closely related with arteriosclerosis and hypertension. The effects of acupuncture with Baihui on arterial stiffness are discussed.

2. Materials and Methods

All experiments were carried out according to the guidelines laid down by the Heisei Rehabilitation College Ethics Committee and under the terms of the Declaration of Helsinki. All subjects gave written, informed consent.

2.1. Measurements of hemodynamic functions

Twenty-five healthy male volunteers (25.3±2.1 years old), with an average body mass index (BMI) of 22.8±1.1, no cardiac disease, and not taking medications, were studied during fasting, abstaining from caffeine, alcohol and smoking for over 8 hours. Subjects were allowed to acclimatize for at least 30 minutes before the start of acupuncture treatments which involved manual acupuncture in Baihui (GV20) carried out in a sitting position at room temperature (25ºC) in the morning. The Baihui acupuncture point was stimulated for 20 minutes and parameters of hemodynamic functions measured for 20 minutes during treatment and for 40 minutes post-acupuncture using automated applanation tonometry (HEM-9000AI, Omron Healthcare, Kyoto, Japan).

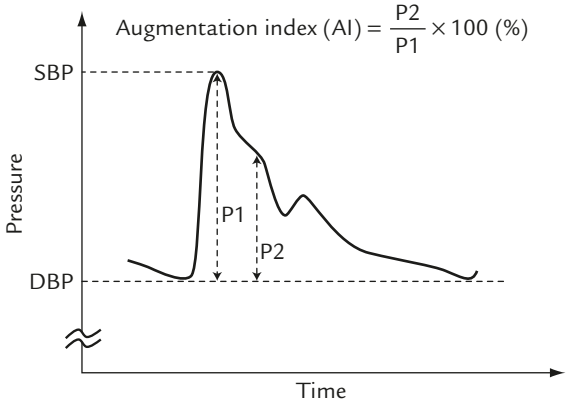

Figure 1 Radial arterial pressure contour.

2.2. Measurements of AI and CBP

An AI in the seated position has been established as a reflection coefficient (Figure 1). The AI was determined by a computer algorithm developed from noninvasive pressure and flow data [2] and, concurrently, the CBP was automatically estimated using a computer algorithm.

The recorded values were compared by paired *t*-test with analysis of variance (ANOVA). A *p*-value less than 0.05 was considered to be statistically significant. Data were expressed as the mean±SEM.

3. Results

Modulation of hemodynamic functions by acupuncture treatments with Baihui (GV20) was examined for 25 healthy volunteers. Prior to, during, and after acupuncture treatments, the hemodynamic effects were observed periodically. In post-acupuncture, the effects lasted for 30–40 minutes and no subjects complained of any adverse symptoms.

3.1. Effects on the blood pressures

In pre-acupuncture, the systolic and diastolic blood pressures (SBP and DBP) of 25 volunteers were 117.5±5.6 mmHg and 65.2±5.5 mmHg, respectively, and the mean BP (MBP) was 81.9±3.3 mmHg.

During treatment, both SBP and DBP initially decreased and gradually recovered to the control values (Figure 2A) and 15–20 minutes after beginning the treatment, both increased. The maximal enhancement during the treatment was 1.8±0.4% (not significant) in SBP, and 8.1±0.5% ($n=25$, $p<0.05$) in DBP.

After treatment, both SBP and DBP were suddenly reduced (~8–10%) and then elevated gradually. The enhancement of SBP was 10.1±0.3% (n=25, p<0.05).

3.2. Effects on the heart rate

The HR in pre-acupuncture was 67.0±2.6 beats/min (n=25). During treatment, the HR initially increased for 2 minutes and then, decreased time-dependently but not significantly (6.4±0.3%, Figure 2B). Post-treatment, the HR was still depressed for 40 minutes, and the average depression at −7.2±0.2% (n=25, p<0.05) 40 minutes after the treatment.

3.3. Effects on the AI

The AI pre-acupuncture was 62.3±2.5% (n=25) and was enhanced initially for ~2 minutes into treatment, after which the AI slowly decreased but was consistently above the control value (Figure 2C). The maximal enhancement of AI was 8.4±0.4% (n=25, p<0.05). The AI value failed to alter significantly during the post-treatment period.

3.4. Effects on the CBP

The effect on CBP was very similar to the observed alterations in SBP and DBP (Figure 2D). The CBP in pre-acupuncture was 98.0±6.1 mmHg, decreased during the initial 10 minutes of treatment, and subsequently increased at 15–20 minutes into the treatment. During and post-treatment, the CBP increased but not significantly (~2%).

The above described parameters were affected during the acupuncture treatments and all changes lasted to some extent for 40 minutes post-treatment; the percentage changes are summarized in Figure 3.

4. Discussion

Acupuncture is a healing art involving insertion of a needle into an acupuncture point in the meridian. The aim of acupuncture is to stimulate the physiological functions mediated through the meridian. In practice, acupuncture stimulates some sensory nerves and the autonomic nervous system, and induces the recovery of blood circulation [10–12].

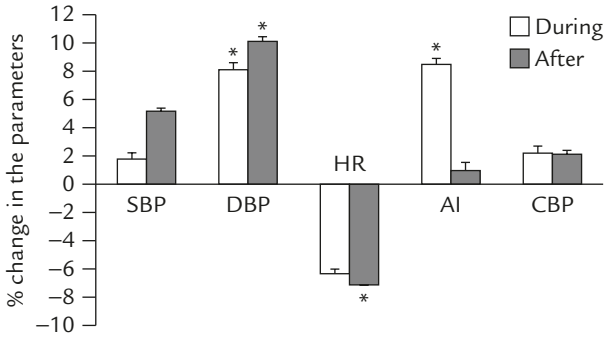

Figure 3 Summary for the stiffness parameters after acupuncture. SBP=systolic blood pressure; DBP=diastolic blood pressure; HR=heart rate; AI=augmentation index from radial artery; CBP=central aortic blood pressure. Values as mean±SEM; *p<0.05 with respect to control value.

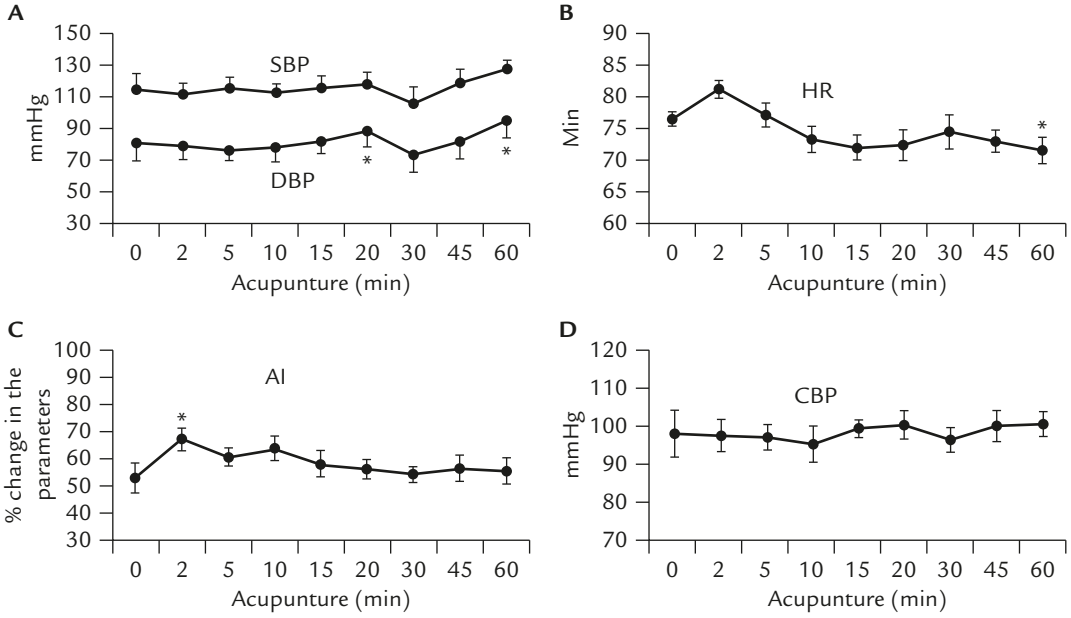

Figure 2 Time-dependent changes in hemodynamic parameters after acupuncture. (A) Changes in blood pressures (SBP and DBP). (B) Heart rate. (C) Augmentation index (AI). (D) Central aortic blood pressure (CBP). Values as mean±SEM; *p<0.05; **p<0.01 with respect to control values.

Many clinical trials have been carried on the effects of acupuncture and especially in analgesia.

Recent technical progress makes noninvasive measurements of the AI possible; the tonometer provides a high fidelity recording of the arterial pressure wave contour under a wide variety of clinical conditions and pulse pressures. Since the reflection wave influences the arterial pulse wave in the ascending aorta during the late systolic phase, it increases the pressure load on the heart when the AI is enhanced [13]. The reflection wave is thus an important physiological phenomenon that partly explains why ankle SBP is higher than the brachial SBP [14]. Recently, Marchais et al [15] have shown that the arterial wave reflections are positively correlated to left ventricular mass in hemodialysis patients.

In general, NO content and NO synthase (NOS) expression become consistently higher at skin acupuncture points or meridians [16]. The mechanisms underlying the increased blood flow induced by acupuncture treatment have been suggested to rely on the activation of thin nerve fibers, which release vasoactive neuropeptides and NO from their peripheral terminals upon activation [17–19] and, as a result, vasodilation occurs and blood flow increases. The resulting decreases in vascular tone (vasodilation) and BP might directly and indirectly contribute to the regulation of brain activity as well as hemodynamic actions.

In this study, however, the acupuncture treatments stimulated hemodynamic functions. The enhancement of hemodynamic effects was marked and the stiffness parameters were rather enhanced. The stimulatory effects lasted during and after the treatments, while heart rate was reduced, presumably a response to the enhancement of blood pressure. On the other hand, the AI was enhanced during treatment but decreased almost to the control value in the post-acupuncture period.

The central aortic augmentation has been evaluated noninvasively and simultaneously by mathematically transforming the radial artery pulse wave form to the aortic pulse waveform [20,21]. The pulse wave velocity of brachial to ankle arteries (baPWV) is a modality to assess arterial stiffness noninvasively and expresses not only the aortic stiffness but also the tone of peripheral muscular arteries [22,23].

Clinically, the AI has been proposed as a specific marker for evaluation of vascular aging, instead of the baPWV. In this study, the applied acute acupuncture increased the vascular wall tone and greatly enhanced the AI, presumably due to stimulation of the central and sympathomimetic nervous systems. The acupuncture treatment with Baihui (GV20) caused the enhancement of arterial stiffness, quite different from previous reports [24–26]. The discrepancy may have arisen for several reasons, including the chance that the acute effects induced by a single acupuncture treatment might not be consistent with improvements induced by a chronic or long term treatment and that there might be different physiological functions induced by different acupoints. Further studies are needed to elucidate the origin of these discrepancies.

In conclusion, acupuncture treatment has been accepted as an alternative medicine in many countries, demonstrating curative effects for many chronic diseases and with few of the side effects caused by some drugs. A clinical acupuncture treatment with Baihui (GV20) is usually carried out for headache, stroke, dizziness, and anxiety. The acute treatments with acupuncture in this study produced significant effects on the arterial stiffness parameters even in healthy volunteers. In practice, chronic treatment would be expected to have more beneficial effects, but might alter the arterial pulse waveforms which accompanied the enhancement of BP. These results suggested the importance of employing acupuncture in basic and clinical studies of the stiffness and aging of vascular beds. At the same time, the application of acupuncture might produce dangerous risks for patients with cardiac and brain diseases, in which case application of even a single acupuncture treatment needs to be considered carefully for possible health effects, especially for possible aggravating effects on cardiovascular diseases.

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